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ENERGETIC SOLAR PARTICLE AND GEOMAGNETIC STORM STUDY.(U)  
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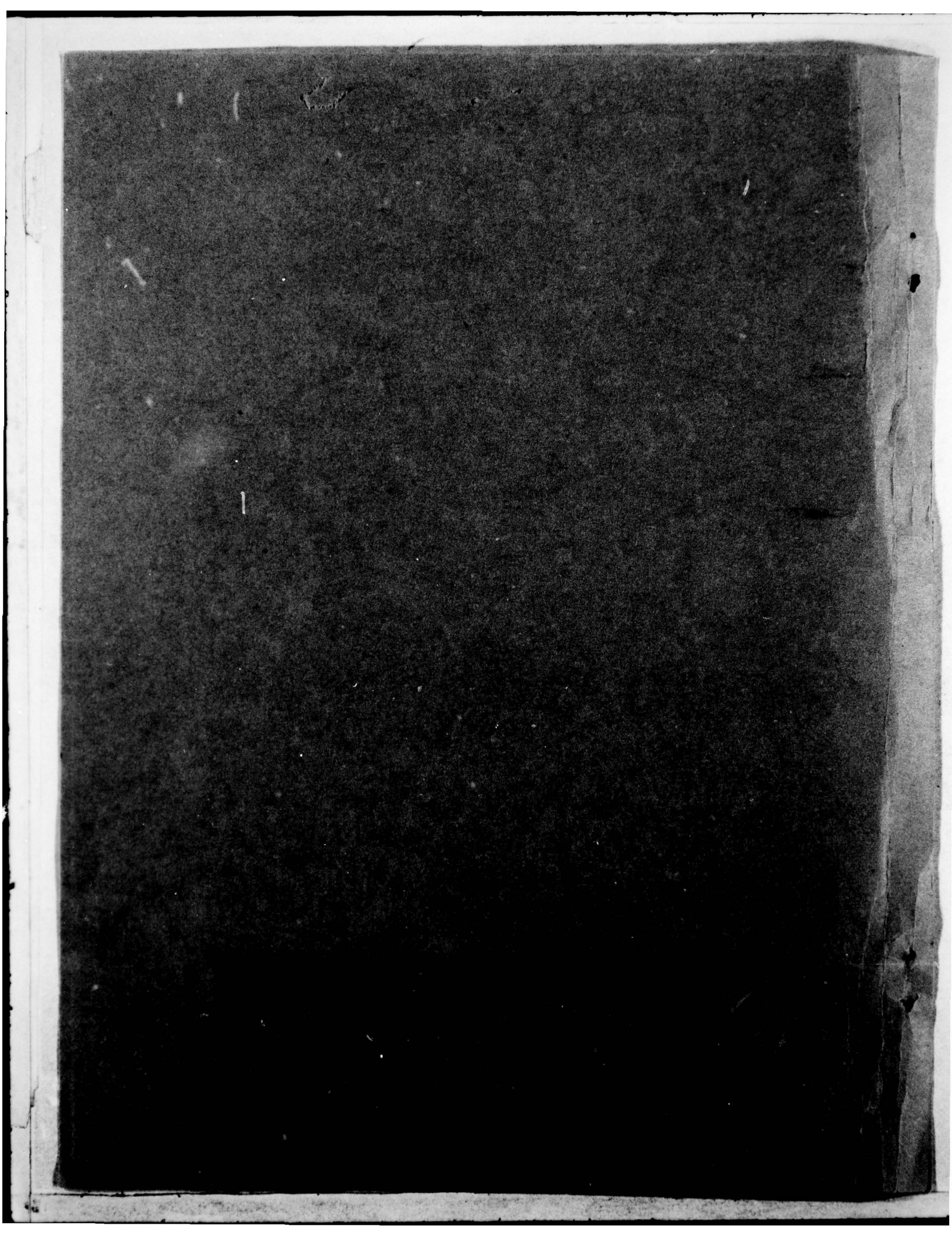
ENERGETIC SOLAR PARTICLES AND COSMIC RAY STORMS

O. C. Kohler  
H. C. Prince-Prince  
E. C. Prince

Report of the Committee on  
the Status of the  
Solar Wind, 1978

1. Solar Wind  
2. Solar Wind  
3. Solar Wind

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This final report consists of a brief administrative statement describing the purpose and progress of the research, the funding of the research, the personnel who participated in the program, and brief description of the scientific reports prepared under this contract. Three scientific reports have been completed: → next page		

- A: "Survey and Comparison of Solar Activity and Energetic Particle Emission in 1970;" H. W. Dodson-Prince, E. R. Hedeman, and O. C. Mohler; AFGL-TR-77-0222, published 30 September, 1977.
- B. "Solar and Geophysical Associations with the Principal Energetic Particle Events in 1971 and 1972;" H. W. Dodson-Prince, E. R. Hedeman, and O. C. Mohler, AFGL-TR-78-0266, published 31 October 1978.
- C. "Study of Geomagnetic Storms and Solar Flares in the Years of Increasing Solar Activity in Cycles 19 and 20 (1955-1957; 1965-1968)." H. W. Dodson-Prince, E. R. Hedeman, and O. C. Mohler; AFGL-TR-78-0267, published 31 October, 1978.

Detailed scientific results are contained in these reports.

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**Final Report for Contract F19628-76-C-0240**

**ENERGETIC SOLAR PARTICLE AND GEOMAGNETIC STORM STUDY**

- I. Summary of the Research Programs Carried Out under this Contract
- II. Funding for the Research
- III. Personnel
- IV. Scientific Reports Prepared Under this Contract
  - A. Scientific Report No. 1; AFGL-TR-77-0222
  - B. Scientific Report No. 2; AFGL-TR-78-0266
  - C. Scientific Report No. 3; AFGL-TR-78-0267

## I. SUMMARY OF THE RESEARCH PROGRAMS CARRIED OUT UNDER THIS CONTRACT

This contract had two distinct objectives, (a) study of solar causes of energetic particle enhancements in certain years, and (b) the identification of solar phenomena associated with the onset of geomagnetic storms in the early years of solar cycles 19 and 20. Towards the first of these objectives, detailed solar and geophysical circumstances have been studied prior to all energetic particle events in the three years 1970, 1971, and 1972. Definitive evaluations have been reached for the principal proton enhancements in these years. They have been reported to AFGL in successive Quarterly Status Reports for the contract and in two Scientific Reports, viz AFGL-TR-77-0222, "Survey and Comparison of Solar Activity and Energetic Particle Emission in 1970," and "Solar and Geophysical Associations with the Principal Energetic Particle Events in 1971 and 1972." Work towards the second objective has included consideration of solar and geophysical phenomena prior to each of the "principal" geomagnetic storms in the years 1955-1957 and 1965-1968. These are the years of increasing activity in solar cycles 19 and 20, years when sporadic (usually flare-associated) storms are abundant. The results of these geophysical evaluations were reported in Quarterly Status Reports Nos. 5-7 and are summarized in the Scientific Report No. 3 "Study of Geomagnetic Storms and Solar Flares in the Years of Increasing Solar Activity in Cycles 19 and 20 (1955-1957; 1965-1968)."

## II. FUNDING FOR THE RESEARCH

Funds totaling \$50,000 were made available to the observatory for support of the above programs during the 26-month interval in which the work was carried out. The funds were used primarily for staff salaries as can be seen



in the following statement of expenditure from the contract through September 30, 1978. A balance of \$123.99 remains unspent.

Summary of Expenditures - September 30, 1978  
Contract F19628-76-C-0240

Salaries and Wages	\$23,621.39
Fringe Benefits	4,973.75
Supplies	328.91
Travel	<u>269.88</u>
Total direct costs	29,193.93
Indirect Costs	<u>20,682.08</u>
Total Charges to Contract	\$49,876.01
Balance	<u>123.99</u>
Total Contract	\$50,000.00

### III. PERSONNEL

The research programs carried out under this contract were made possible by the cooperative effort of all members of the staff of the McMath-Hulbert Observatory. The staff members included Dr. O. C. Mohler, Director of the McMath-Hulbert Observatory and Professor of Astronomy, Miss E. Ruth Hedeman, Associate Research Scientist, Mr. Clifford P. Bennett, Supervisor of Technical Services, Mrs. Carol Omohundro, Secretary and Data Assistant, and the Assistants in Research, Messrs. Andrew deRadder, Frederic Stewart, and William Marquette. Funds from this contract were used to support, in part, the salaries of four of the non-academic members of the observatory staff. Dr. Mohler was the Project Supervisor. Miss Hedeman carried out the major part of the basic research on which the program was based. Dr. Helen Dodson-Prince, Professor Emeritus, participated in many aspects of the program.



#### IV. SCIENTIFIC REPORTS PREPARED UNDER THIS CONTRACT

The principal scientific results obtained during the programs supported by this contract have been presented in three scientific reports published during the course of the contract. The reports organize evaluations of the most probable solar causes of energetic particle events at earth in 1970, and 1971-72, and of the principal geomagnetic storms in the years 1955-1957 and 1965-1968. The three reports are described below.

- A. "Survey and Comparison of Solar Activity and Energetic Particle Emission in 1970," H. W. Dodson-Prince, E. R. Hedeman, and O. C. Mohler; AFGL-TR-77-0222, published 30 September, 1977.

Abstract:

Solar activity in 1970 was at a relatively high level with the number of "major" flares and important centers of activity reaching maximum numbers for all of cycle 20. Satellite data, primarily from Explorer 41, provided evidence for at least 152 distinct energetic particle enhancements during the year. These events have been compared with concurrent solar activity. All but one of the 13 particle events associated with Polar Cap Absorption in 1970 have been identified with specific solar flares. For the 50 proton events with energies 19-80 or  $>60$  MEV, 72% have reasonably sure solar or geophysical sources. Of the 59 purely low energy particle events (1-10 MEV) only 39% could be assigned probable solar associations. For the numerous low-energy particle events without confident solar associations, there were assorted time coincidences with geomagnetic storms, sector boundary passages, the development of new regions on the disk, and the central meridian passage of significant centers of activity. At the present time, the significance of these solar

and geophysical phenomena for particle enhancement is not known.

Although the intervals of lowest solar activity, September and October 1970, corresponded to the times of lowest levels in observed particle enhancement, identification of the five greatest centers of activity in 1970 did not lead directly to the solar sources associated with the majority of the most energetic particle (19-80 and/or >30 MEV) enhancements at earth in that year. Strong solar magnetic fields and interplanetary circumstances apparently influenced significantly the propagation of energetic particles from sun to earth. In spite of this situation, the 23 "greatest" flares (CFI  $\geq 11$ ) formed a class of solar phenomena in 1970 that were associated with the onset or continuation of increased particle enhancement in the neighborhood of the earth regardless of all other circumstances.

- B. "Solar and Geophysical Associations with the Principal Energetic Particle Events in 1971 and 1972," H. W. Dodson-Prince, E. R. Hedeman, and O. C. Mohler; AFGL-TR-78-0266, published 21 October 1978.

Abstract:

For 1971 and 1972, 211 distinct, energetic particle enhancements have been identified. Solar and geomagnetic circumstances prior to each of these proton increases have been evaluated. For 97 of the particle enhancements, confident flare or geomagnetic associations could be established. These events included 26 relatively high energy (19-80 or >60 MEV or PCA) proton enhancements. An additional 17 high energy increases were observed, but assured solar or geomagnetic associations could not be established. Tabulations have been prepared of solar and geomagnetic circumstances prior to all



events with assured flare or geomagnetic associations and/or high energy proton detection. The tabulations of this report provide solar and geomagnetic data for approximately 54% of the identified energetic particle events in 1971 and 1972. The remaining events included only those with lower particle energies and the less confident solar or geophysical associations.

- C. "Study of Geomagnetic Storms and Solar Flares in the Years of Increasing Solar Activity in Cycles 19 and 20 (1955-1957; 1965-1968)," H. W. Dodson-Prince, E. R. Hedeman, and O. C. Mohler; AFGL-TR-78-0267, published 31 October 1978.

Abstract:

Solar circumstances prior to the 245 geomagnetic storms with maximum values of 3-hourly  $K_p$  as great as 5 in the years 1955-1957 and 1965-1968 have been evaluated. The years studied were those of increasing activity in solar cycles 19 and 20. To assist in this study, a Comprehensive Flare Index based on the flare's  $H\alpha$ , ionizing, and radio frequency radiation has been used. Of the 245 storms in the seven years studied 62% were considered to be flare-associated, 30% were primarily sequential, and only 8% remained as "problem" cases. Most of the severe storms were associated with flares. Sequential storms were primarily of moderate severity.

Flares that were found to have been followed by geomagnetic storms were, in general, important solar events. For only 5 storm-associated flares (with complete data) was the  $H\alpha$  importance less than 2 and the Comprehensive Index also less than 6. A preponderance of the storm-associated flares occurred in the western hemisphere of the sun but the most severe



storms were associated with flares strongly concentrated toward the central part of the solar disk.

The most important flares tended to be associated with the most severe storms. Flare criteria that include ionizing and radio frequency emissions as well as optical data apparently assist in the recognition of flares associated with subsequent geomagnetic storms.